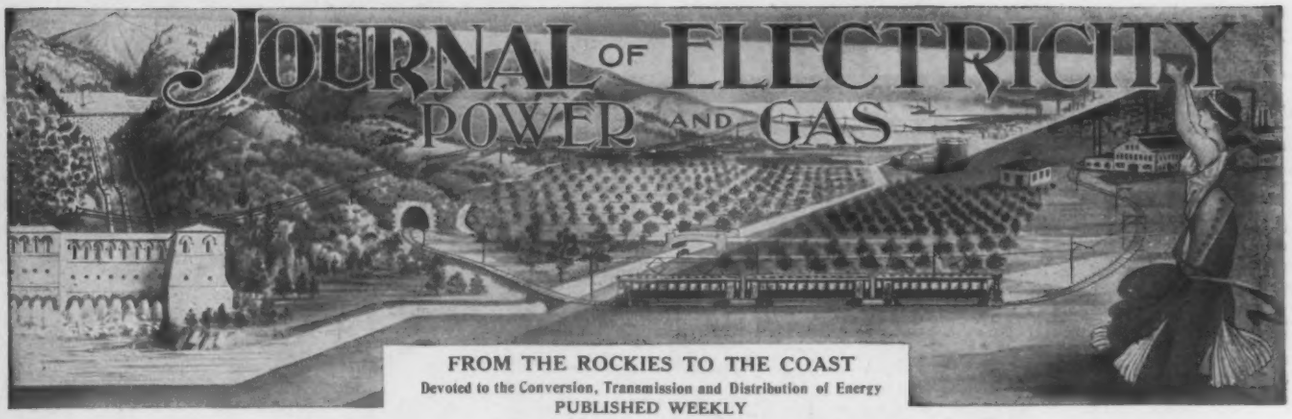
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POWER AND GAS
FROM THE ROCKIES TO THE COAST
Devoted to the Conversion, Transmission and Distribution of Energy
PUBLISHED WEEKLY

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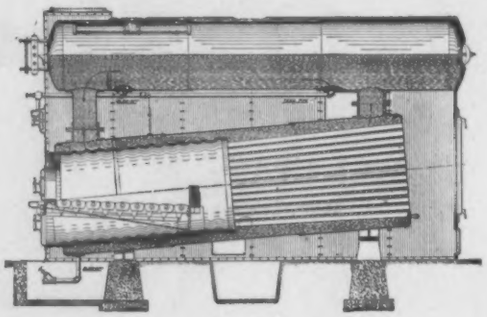

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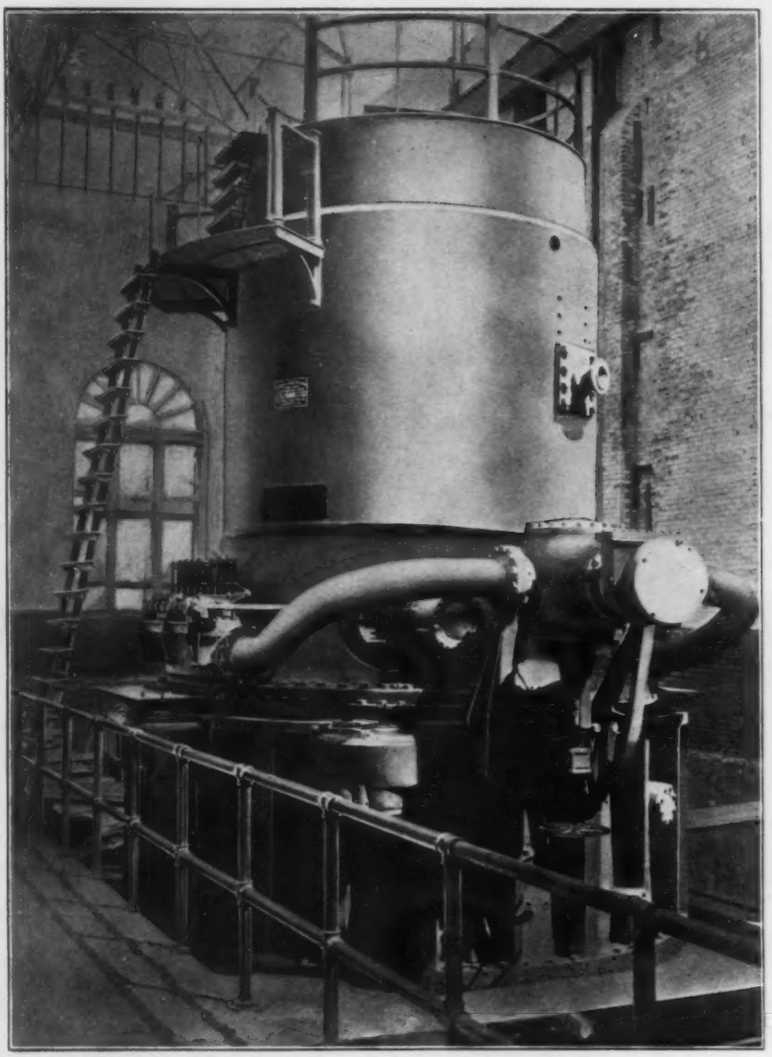
THE STEAM TURBINE

By F. E. VICKERS

The history of the steam turbine dates back more than 2,000 years to an invention of the Egyptian priests, described by Hero of Alexandria about 120 B. C. This invention consisted of a hollow sphere supported by and free to rotate on two trunnions through which steam was admitted to the sphere from a boiler underneath. On the equator of the sphere were two bent pipes connected with the interior, and the reaction of the steam issuing from these bent pipes caused the sphere to rotate on its trunnions.

The next rotary steam engine of which we have any record was an impulse steam turbine, designed by Giovanni Branca in 1629. This machine was similar in its action to the well-known impulse water-wheel of the present day. Steam was generated in a boiler and was discharged from a nozzle against a series of blades or paddles fastened to the periphery of a wheel, this wheel being mounted on a shaft which was free to rotate. So far as is known, this is the first turbine whose output was applied to a useful purpose.

It was not until about twenty-five years ago that the real development of our present steam turbine began, with the work of DeLaval in Sweden and Parsons in England. The steam turbine as developed by Parsons is of the reaction type, and consists of a long cylinder mounted on a horizontal shaft and carrying a series of rows of curved blades. The cylinder is surrounded by a casing carrying other rows of stationary blades between those on the cylinder, but curved in the opposite direction; the purpose of these being to reverse the direction of the steam after it has passed one row of moving blades and give it a proper direction of discharge against the next row of moving blades. Steam at boiler pressure is admitted intermittently near one end of the cylinder and is gradually expanded as it passes among the blades to the other end, where it is exhausted to a condenser after having given up most of its energy to the rotating cylinder. The cylinder has several sections of different size, the diameter of the sections and the length of the blades increasing toward the discharge end. On account of the end thrust, due to the difference in steam pressure and diameter at the two ends of the cylinder, a set of dummy balancing pistons of diameters corresponding to the diameters of the cylinder sections is provided to prevent excessive thrust on the bearings. In this type of turbine it is necessary to restrict the radial clearances at the ends of the blades and on the balancing pistons, in order to prevent excessive leakage of steam.



Photograph by J. H. Mentz.

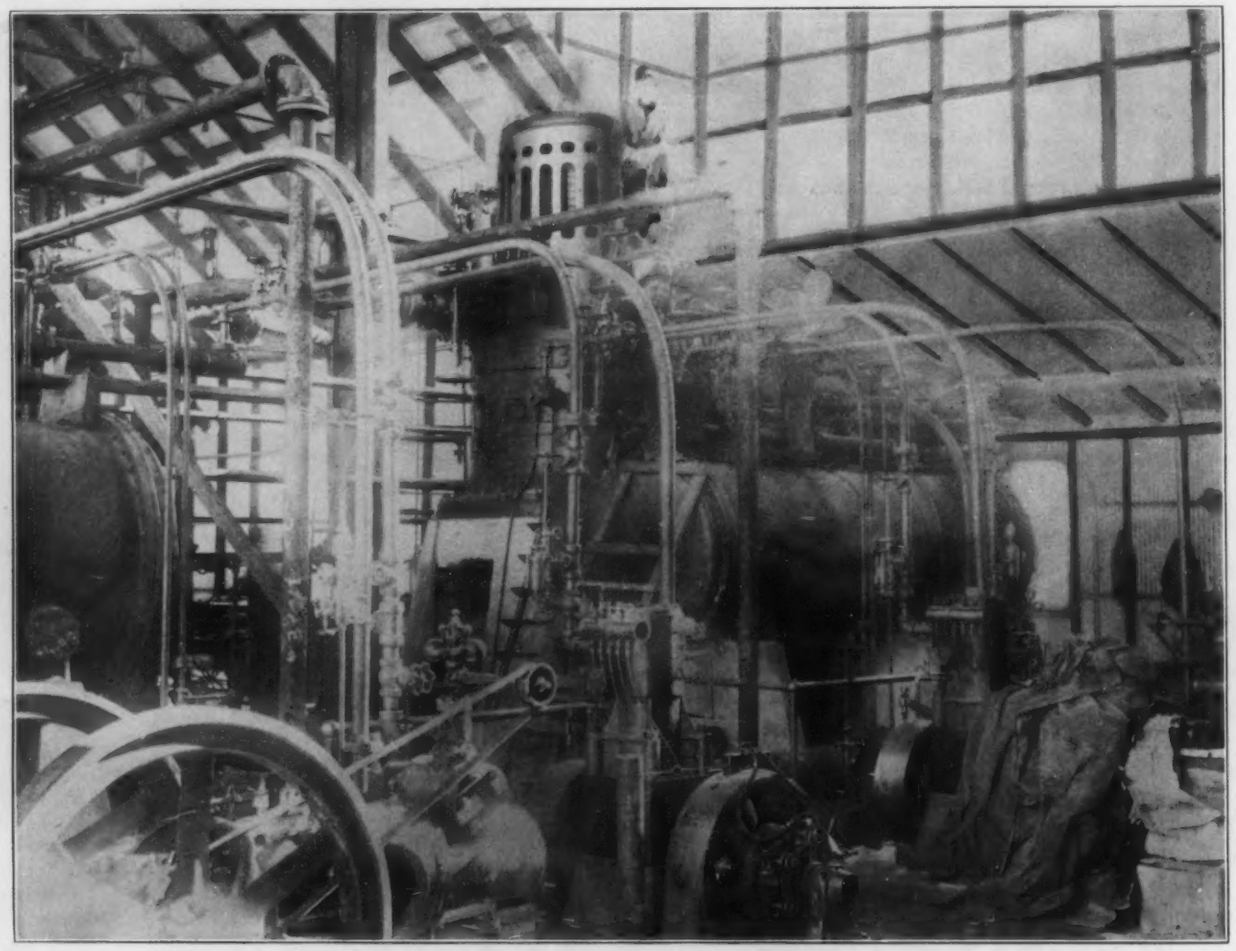
5,000 K. W. Curtis Steam Turbine Installed by the United Railroads of San Francisco.

About fifteen years ago, Mr. C. G. Curtis, of New York, began the experimental investigation of what has since been developed into the Curtis steam turbine as manufactured by the General Electric Company. The Curtis steam turbine is an impulse machine, and consists of one or more sections or stages in which the work is proportionally divided. In each stage, steam is admitted through a series of nozzles and impinges on a number of crescent-shaped radial buckets secured to the periphery of the wheel. Each wheel is provided with two or more rows of buckets, and between the rows of buckets

are placed stationary intermediate buckets also crescent-shaped but curved in the opposite direction from the moving buckets. Steam admitted through the valves is expanded in the nozzles to give a suitable velocity, impinges on the first row of buckets, to which it gives a portion of its energy, then passes through the stationary buckets which give it a suitable direction for giving up another portion of its energy to a second row of buckets, and so on. Partly in order to reduce the speed of the turbine shaft, and partly to improve the economy of the turbine, it has been found desirable to increase the number of stages in certain machines. Where more than one stage is used, the action of the steam in each stage is practically the same. In the first-stage nozzles, the steam may be expanded from a boiler pressure of 175 pounds down to 50 pounds stage pressure. In the second stage, the expansion might be from fifty pounds down to five pounds, and so on down to a 28-inch vacuum. At no point does steam at boiler pressure reach any of the wheels, and as the steam pressure in each stage is equal on all sides of the wheel, there is no end thrust to be taken care of. Steam expanded from 150 pounds pressure down to atmospheric pressure will acquire a velocity of nearly 3,000 feet per second. Theoretically, to get all the energy out of this steam with a single row of buckets, a bucket speed of one-half the steam velocity would be required, namely, 1,500 feet per second. In order to get this peripheral speed with a wheel one foot in diameter, a shaft speed of over 28,000 revolutions per minute would be required. By using two rows of buckets, allowing the steam to give up half its energy on the first row, and re-directing it to the second row of buckets, we can reduce the shaft speed to one-half. By increasing the number of stages, reducing the expansion of steam in the nozzles of each stage, the velocity with which it strikes the buckets is considerably reduced, permitting a further reduction in the shaft speed. By increasing the diameter of the wheels, a further decrease is made, bringing the shaft speed down to a moderate number of revolutions per minute.

The 500-kilowatt alternating-current machine, as now made, has a two-stage turbine, each stage consisting of three rows of buckets with two rows of intermediates. The shaft is placed vertically, and the weight of the revolving parts is taken care of by means of a step bearing, to be more fully described later. The general arrangement of all the alternating-current sets, from 500 kilowatts up, is the same. At the bottom, and resting on the foundation, is the exhaust base, connected with a condenser, and above it and separated by diaphragms, are the steam turbine wheels, surrounded by a suitable casing which carries the stationary blades or intermediates. On the top of this casing are placed the steam admission valves and nozzles, varying in number and size with the capacity of the machine, but in all cases covering only a small portion of the periphery of the first-stage wheel. There seems to have been a general misunderstanding on this particular point among steam-engine men, a great many of whom are under the impression that the admission nozzles extend entirely around the periphery of the wheel.

The generator is placed above the steam turbine and at the very top is the governor. There are three guide bearings to steady the shaft; one just above the step bearing, one between the steam turbine and the generator, and one between



500 K. W. Curtis Turbine at Monterey, California.

the generator and governor. The lower guide bearing is lubricated with the oil or water which has passed through the step bearing. The upper two guide bearings are supplied with oil from a separate source.

The oil, after passing through the various bearings, is returned by gravity to a filter from which it is again pumped to the bearings, so that there is no waste, the same oil being used over and over again. No oil comes in contact with the steam, and the condensed steam may therefore be used over and over again without purifying.

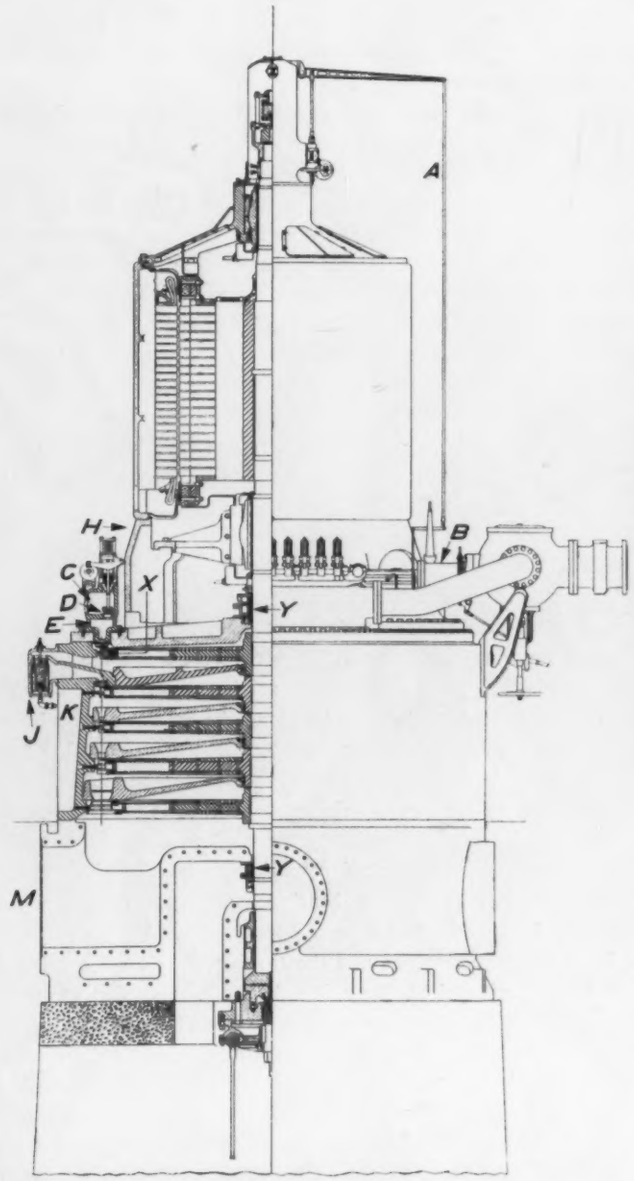


Fig. 1. Half Cross Section of 9000 Kw. Curtis Turbine-Generator

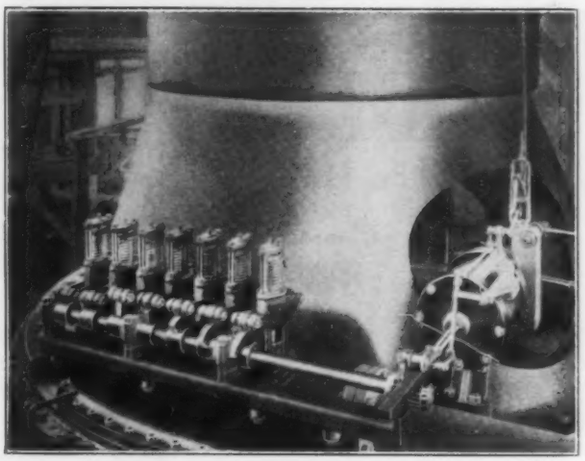
In place of the exhaust base at the bottom of the turbine and a separate condenser, the turbine can be furnished if desired with a condenser base. This condenser base is made with ample strength to support the turbine and is provided with sufficient space for the condenser tubes.

Steam is admitted to the turbine through a throttle valve so arranged that it may be opened by hand and closed either by hand or automatically by means of an emergency trip adjusted to operate should the speed increase a predetermined amount above normal, usually 10 to 15 per cent.

A type of emergency governor commonly used consists of a steel ring surrounding the turbine shaft just under the middle guide bearing. This ring is made heavier on one side, the additional weight being counterbalanced by a spring which can be so adjusted that at a given speed the unbalanced weight of the ring will overcome the tension of the spring, and the ring will be thrown out on one side, eccentric to the shaft, and strike a trigger which trips the throttle valve.

The speed governor is mounted directly on the upper end of the main shaft and is of the spring loaded fly-ball type. This governor is connected through a series of rods to the mechanism operating the steam admission valves on the turbine.

An auxiliary spring is provided, which may be adjusted either by hand or by means of a motor controlled from the switchboard, for slightly changing the tension on the governor parts, thus permitting small variations of speed for synchronizing. One of the latest methods of handling the steam admission valves is by means of hydraulic control. With this type of control the governor mechanism is connected to a small pilot valve, which admits oil to one or the other side of the piston of a hydraulic cylinder, the piston rod being connected through a rack and pinion to a cam shaft. The cam shaft has one cam for each of the admission valves, the cams being set so as to open or close the valves in succession as the load changes.



Hydraulic Cylinder and Valve Gear of 3000 K. W. Turbine.

The valves are opened by the action of the cams and closed by springs. Steam from the steam chest, after passing through the valves, goes directly to the nozzles, in which it is expanded, and then on to the first stage wheels. One nozzle is provided for each valve. The hydraulic cylinder and the valves themselves are of very rugged construction and are simple in operation. A by-pass valve is provided for passing first stage steam through an extra set of nozzles on to the second stage wheel in case of overload.

Two different types of bucket construction are used. On the smaller sizes the buckets are milled out of solid metal by means of special machinery, but on the larger sizes the buckets and intermediates are cut from bars of extruded metal and dovetailed to a solid segment, which in turn is riveted

on to the wheel disc. Over the ends of the buckets is riveted a retaining strip or shrouding which supports the buckets. In the larger sizes each wheel is built up of two steel discs, one on each side of a steel spider. Between the discs and around the ends of the spider arms is a spacing ring. A groove is turned in the wheel disc near its outer edge and a projection on the bucket section fits into this groove, the section being held in place by rivets. The wheels in all stages are of practically the same diameter, but the length and the pitch of the buckets is gradually increased in successive rows and stages to take care of the increasing volume of the steam as it expands.

At present the larger alternating current turbine generators are being built with a smooth core field in place of the definite pole field which is common with ordinary alternating current generators. The definite pole fields are still furnished,

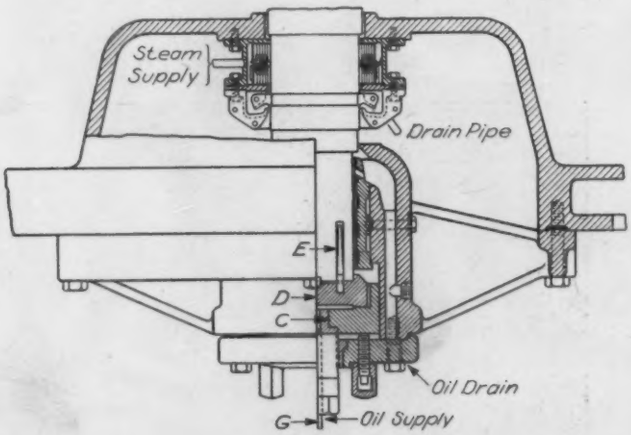


Fig. 7
Step-Bearing for Vertical Type Turbine

however, in certain machines, the pole pieces being very rigidly fastened to a laminated core.

The armature construction does not differ materially from that of other alternating current generators, but special attention is given to the question of ventilation, owing to the concentration of generator losses in a much smaller space than in ordinary slow-speed, engine-driven generators. In certain machines a special casing or ventilating hood is provided for the top of the armature, having a flanged opening for bringing cool air from outside to the generator.

W. L. R. Emmet, in a lecture before the Schenectady Section last November, called attention to the fact that generator losses of 3½ per cent in a 14,000-kilowatt turbine set would represent an amount of heat about equal to that of the furnace of a 60-horsepower boiler, so it is readily seen that the question of generator ventilation is of vital importance.

The step-bearing consists of two cast-iron blocks, one of these fixed to the lower end of the shaft and rotating with it, and the other stationary. The oil or water for separating the step blocks is pumped up through the center of the lower block after having passed through a baffler, the purpose of which is to make the pressure on the step-bearing more uniform. This baffler is provided with a screen to prevent the admission of foreign matter between the step blocks. The pressure required to support the rotating element varies from about 200 pounds per square inch on the smaller machines up to approximately 1000 pounds per square inch on the largest size. The entire weight of the rotating parts is supported on a film of lubricant, either oil or water, forced out between the step blocks by the pump pressure, the thickness of this film being probably .002 or .003 of an inch. By this method of supporting the weight of the moving element, the friction of the turbine is so reduced that even in the largest sizes the rotating element, having a weight of many tons, may be set in motion by the pressure of one's finger.

The entire unit when assembled is a very solid and compact machine, both the floor space and the cubic space occupied by a turbine generator set being very much smaller than required by an engine set of the same capacity, and a much smaller foundation being required. The Curtis type of steam turbine is the only one having shaft speeds sufficiently low to be satisfactorily direct connected to direct-current generators. Direct-current Curtis turbine sets are now built in sizes from 400 watts, for locomotive headlight work, up to 2500 kilowatts. In order to give easy access to the commutator, brushes, etc., all direct-current turbine generating sets are now being built with horizontal shafts.

For exciter service in large power stations and for building lighting and other isolated stations, as well as for electric railway service, the direct-current machines are admirably adapted. Owing to the small space required for these machines, they are particularly suitable for installation on board ship, in office buildings, or any other place where space is at a premium.

The nozzles of these direct-current machines are similar in construction to those in the large machines. The governor and valve mechanism are different from those of the vertical shaft machines and vary with the different sizes, the greatest simplicity being aimed at in each particular case. The 35-kilowatt machines have but two bearings, the turbine wheels being overhung. The 75-kilowatt, direct-current turbine set has four bearings, the generator being connected to the turbine by a flexible coupling. In this size the governor is operated by oil supplied from a pump direct-connected to the turbine. The pump also furnishes oil for lubricating the bearings. The 100-kilowatt size has two bearings. The governor is a mechanical one, operated from a worm gear on the shaft. This is a two-stage machine and the turbine wheels are overhung. Oil is circulated through the bearings and the governor mechanism by means of a pump operated from the turbine shaft. Carbon packing is provided on the high pressure side of the turbine, next to the main bearing, and also in the diaphragm between the two wheels.

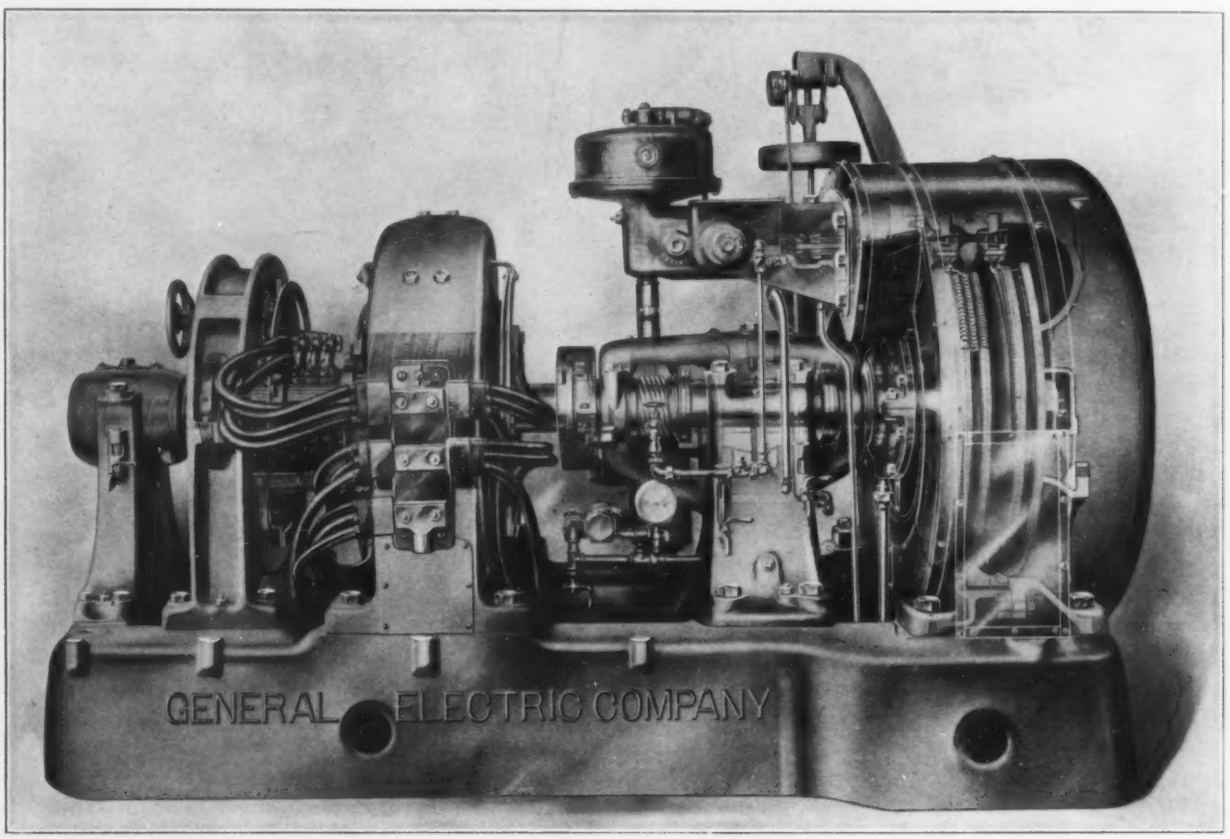
Various types of carbon packing are used to prevent the escape of steam along the shaft. On the 100-kilowatt size it consists of sets of two rings each, each ring being made up of three pieces, the two rings being so put together as to break joints, and the assembled packing being mounted in a suitable casing. Various modifications of this arrangement are used in other sizes.

The efficiency curve of the Curtis turbine is very flat, so that the economy is approximately the same over widely varying loads. With the reciprocating engine, on the contrary, the economy drops off very rapidly both on light load and on overload.

Several low-pressure turbines have been developed for installation in stations already equipped with reciprocating

engines. By the use of these low-pressure turbines it is possible to increase the output of non-condensing steam engine stations 70 to 90 per cent, and of condensing steam engine stations 40 to 60 per cent, without any addition to the boiler capacity and without any increase in the consumption of fuel. These turbines are furnished without any governor, being synchronized with the engine-driven generators, and their speed being regulated indirectly by the engine governor.

It may be of interest to note that while the first Curtis turbine was completed and ready for service in February, 1903, a little more than five years ago, there are at present in use or on order, a total of 1182 Curtis turbines of all sizes, having a total capacity of 1,080,290 kilowatts. Of these, 620 units are of 500-kilowatt capacity or greater, with a total capacity of 1,043,150 kilowatts. On the Pacific Coast there are now installed or on order 59 machines, having a total capacity of 57,135 kilowatts. Of these, 27 machines, with a total capacity of 56,000 kilowatts, are of 500-kilowatt size or larger.



Phantom View of Curtis Turbine.

What claims to be the steepest railway line in the world is that recently opened near Bozen, in the Tyrol. The Mendel Railway, with a gradient of 64 in 100, and the Vesuvian, with 63, have hitherto held the record. But the new line in its steepest part rises 70 in 100 and in other parts 66. It leads up the mountainside to Virgil Terrace, on the river Eisach. The system employed is that of the electrical wire rope and the ascent is made at the rate of five feet a second, or five minutes for the whole distance. The car of four compartments carries thirty-two passengers.

WIRELESS ON AIRSHIP.

The new German military airship made an ascent recently for the purpose of making experiments in wireless telegraphy. The experiments were very successful at a height of 600 feet. It had been feared that danger existed in electric waves generated in close proximity to an airship, it being thought that they might ignite the gas. Numerous tests, however, on a small scale on the earth level were made before risking the operation of transmitting messages high in the air. The experiment is regarded in military circles as very important, demonstrating as it does the possibility of sending messages from airships without danger.

Experiments by a French scientist show that certain vegetables grow fifteen times as fast under red light as under blue light. The latter, however, has great preservative power, keeping ripe fruit without decay for several weeks.

The highest head hydro-electric power plant in the world has been designed for a Norwegian factory. The total head is 3,287 feet, the water being taken through a seven-mile tunnel from a lake 3,536 feet above sea level to supply six turbines of from 12,200 to 14,600 horsepower each.

The Pennsylvania Railroad contemplates electrifying its New York City terminal and the tunnels in which trains will run under the Hudson and East Rivers. Engineers have inspected the equipment of the New York Central terminal and estimate the cost of the proposed work at about twenty million dollars.

ATTITUDE OF THE LAW TOWARD ELECTRICITY.

By Emerson W. Read.*

Not only does a distributer of electricity owe this duty of care and responsibility to the public and its own servants; just as great a responsibility must be borne in the distributer's relations with its customers and patrons. The contractual relation between distributer and consumer does not lessen the very high degree of care and skill which must be exercised in placing this commodity in the hands of the consumer.

It must be remembered that the ordinary consumer has a very deficient knowledge of electricity; that much danger attaches through this lack of knowledge; as a result whereof, great caution must be observed by the distributer for the safety of the consumer, his servants, and his patrons. Particularly is this so as regards the agencies and apparatus used in conveying electricity onto the consumer's property. The law never loses sight of the fact that the manufacturer has created an agency, artificial in its nature, that humanity would not be, otherwise, compelled to guard against. The manufacturer circulates among the community a deadly power which he alone can restrain and should restrain. Purchasers of this power can reasonably expect that they may use this power without danger to themselves. Wherefore, the law, while not making an insurer of the manufacturer or supplier, has come to view such manufacturers as quasi-insurers at least. So the distributer's obligations and responsibilities do not end when the electricity reaches the border of the consumer's property. In Denver Con. Elec. Co. v. Foulds (31 Colo. 301), the Court held the distributer liable for an injury occurring to a patron of the consumer while turning on a light, the shock occurring because of a defect in the apparatus furnished.

Instances have occurred where wires, overhanging one another, came in contact during storms, or otherwise, and have burned through because of defective insulation. Companies are required to take notice of such conditions and take precautions against possible dangers arising as a result of such dangerous practices. In Hebert v. Lake Charles Ice, etc., Co. (111 La. 522), such a condition of affairs arose. A storm swept a higher wire down upon a lower wire. Defective insulation allowed the wire to burn through, whereupon it fell upon a passerby. The company was held liable for the death of the passerby, the court deciding that the company was guilty of negligence. In such cases insulation must be carefully inspected and watched. Ordinances and statutes now require, broadly, a liberal use of insulation to prevent injury at points where the public and workmen have a legal right to go. It is not "careful inspection" for a company to properly insulate the wires when they are first hung and repairing at points where damage has occurred to them. "Constant oversight, inspection, and repair to keep them in condition is the duty of their owners. If they fail to discharge this duty they are answerable for the consequences." (See 100 Am. St. Rep. 519.) Under such circumstances ordinary care will not suffice. "Perfect protection" alone will satisfy the law. (O'Donnell vs. Louisville Elec. Co., 21 Ky. Law Rep. 1362, and Potts vs. Shreveport Belt Ry. Co., 110 La. 1.)

As an illustration of municipal control over electrical wiring, Order No. 267 of the ordinances of the city and county of San Francisco may be cited: "All electrical construction, all material and all appliances used in connection with electrical work, and the operation of all electrical apparatus in buildings in the city and county of San Francisco shall be in conformity with the rules and regulations set forth in what is known as the "National Electrical Code." Ordinance No. 353 regulates the placing, installing, and operating of electrical wires, appliances, apparatus, or construction in or on buildings in the city and county of San Francisco. Section 6 of this ordinance says: "Any corporation, co-partnership, or individual who shall continue to fail, neglect or refuse to comply with the provisions of this order shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined . . . or be imprisoned. . . ."

However, to return to the general subject, negligence cannot be imputed to an owner of a cellar whose uninsulated wiring is exposed, if the injured party could only come in contact with the wires by climbing upon a box. Such an instance cannot be classified with cases of dangling wires. (Brusch Elec. Co. vs. Lefebre, 93 Tex. 604, and McMullen vs. Edison Elec. Co., 13 Misc. Rep. 392.)

Merely because the wires of an electrical company are stretched closely to the places habitually used by persons is not, alone, negligence on the part of the company. Such companies cannot be relegated to the outskirts of a town or to obscure and inaccessible places for sites for wires and poles. To properly and adequately supply customers and patrons the company's wires much reach to the doors of the customers. A Texas company suspended wires over a shade awning that stretched in front of a doorway. This awning was not made nor used to support persons. Men did not climb there to make repairs. The court (in Brush Elec. etc. Co. vs. Lefebre, 93 Texas 604) held that such a place was a reasonable place for the company to stretch its wires and danger could not be anticipated from such a use of that space; hence, no negligence on the company's part when the plaintiff was injured while climbing there.

Recent Decisions.

1. It has been recently held in a Pacific Coast State that one who maintains an uninsulated electric wire near a bridge pier is not bound to anticipate that, because of the attractive character of the pier and the birds found there, children might climb the pier and come in contact with the wire, and take precautions to guard against injury to them. That the pier is near a bridge but is not meant to be climbed, although its lattice work may invite climbing, does not require that the owner of the wire insulate it at the pier when the wire is thirty feet above the bridge. (Graves vs. Wash. Water Power Co., 87 Pac. 956, Wash.)

2. A Mississippi court lately held, in accordance with a long line of authority, that it is negligence to attach an uninsulated wire carrying a dangerous electrical current to a tree in a highway having branches extending almost to the ground, which children would be likely to climb. The court took occasion to say in this decision: "Whether this appellee knew that this particular small boy was in the habit of climbing this tree or not, it is clear from the averments of the declaration that it did know the tree, the kind of tree, and knowing that, knew what any person of practical sense would know, that it was just the kind of tree that children might climb into to play in the branches. . . . The immemorial habit of small boys to climb little oak trees filled with abundant branches reaching almost to the ground is a habit which corporations stretching their wires over such trees must take notice of. (Temple vs. McComb City etc. Co., 11 L. R. A. (N. S.) 449.)

*B. L. LL. B., Member of San Francisco Bar.

A HOT BRIDGE.

At Saco, Maine, the steel bridge crossing on the eastern division of the Boston & Maine Railroad recently became charged with electricity, heating the bridge and some of the rails red hot and delaying traffic on the steam and electric roads over an hour. The Saco division of the Portland street railway runs under this bridge. The trolley wire broke away from its fastenings and came in contact with a bolt in the bridge. The engineer of a freight train saw a vivid display of electric flashes as he neared the structure and brought the train to a standstill. The power at the Dunston station was shut out and it was found that the rails on the bridge were red hot and about a foot of the bottom of one of them had burned off. A number of spikes were melted. A new rail was put in before trains could cross the bridge with safety. It was several hours before the bridge cooled off.

TO PREVENT FLOODS.

"Two hundred trillion cubic feet of water on an average falls on the surface of the United States every year," says Dr. W. J. McGee, secretary of the Inland Waterways Commission, and an expert connected with the bureau of soils of the Department of Agriculture. "Two hundred trillion cubic feet of water," said Professor McGee, "is, to the average mind, but two and a lot of ciphers. To be more explicit, it equals about ten Mississippis, and that volume of water is the entire basis of our prosperity. The United States has an area of three million square miles, but that area could be cut directly in twain and with the same amount of rainfall we could sustain the same population that we have today, conduct the same enterprises and raise the same products, a condition which I do not believe most people appreciate. We know very well, if we stop to consider, that the market price of any commodity is dependent on the water supply. We buy land in the eastern half of the United States, and say that there are so many acres in this parcel or in that, but in reality we buy water. This is fundamental. Water is the first of our resources. It is the natural resolvent. It is power, fertility, everything. And being fundamental, values begin with the water supply.

"With the ten Mississippis falling upon the land of the United States every year, two Mississippis run off, thus one-fifth of the water fall from the heavens flows into the sea. Of the eight Mississippis remaining, about five Mississippis are absorbed, passing off into the air, to be precipitated again and again. A fraction, in part, passes into the earth and slowly reaches the ocean, while another fraction is consumed passing into chemical combinations, such as plant growth, etc.

"What we want to do is to minimize the waste of water and maximize the benefits which must accrue to the citizens and country by proper conservation of water supply. If we so control the water that the rivers shall flow in uniform stage, we will solve the problem of inland navigation and make the United States richer by a thousand per cent than they are to-day. In order to do this, we must equalize the run of the streams at the heads of the rivers, and this may be done by dams and reservoirs and scientific cultivation of the soil along the courses of both streams and rivers. The levees of the lower Mississippi have done a magnificent work, but the prevention of floods is better far than all the levees in the world.

"What we want to do is to get back to nature in dealing with water. First, to prevent floods, and, second, to compel the water to run clear and pure. It is a fact that each year the rivers of mainland United States pour into the sea a thousand million tons of richest soil-matter in the form of suspended sediment, an impost greater than all our land taxes combined and a commensurate injury to commerce in the lower rivers which are rendered capricious and difficult of control by the unstable load.

"The difference in the power value alone between controlled and uncontrolled streams would in ten years pay the entire cost of stream control in the United States. And this, coupled with the billion dollars' loss every year through soil erosion, due to floods, would construct a comprehensive system of water control in the United States.

"It seems to me, in view of these statements, that the Congress should authorize the control over the waters in order that this wealth might contribute a thousand fold to man's happiness and prosperity. Notwithstanding all that has been said, I am in hearty sympathy with the President when he said that there was 'a twilight zone' between the federal government and the States, so far as water control is concerned. Both the federal government and the States have shrunk from assuming control over inland waters because they have been fearful of invading each other's rights. What we should aim to do is to so co-ordinate the work on the principle of the greatest good to the greatest number for the longest time, and a comprehensive policy, such as is urged by the National Rivers and Harbors Congress, toward the navigable waters of the nation, would bring untold prosperity and add immeasurably to the nation's wealth."

WATER POWER VS. STEAM POWER.

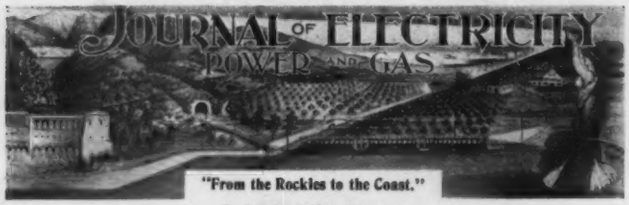
The effect of variable flow upon the value of a water power is difficult to estimate "as regards the point of variability at which a water power becomes of no value." "I am firmly convinced," so says Chas. T. Main, engineer of Boston, "that today there are a great many concerns located upon streams which are so variable as to require an auxiliary steam plant of a size equal to the water-power plant, or nearly so, to which in the past such water power may have been a saving, but which now, if they could begin anew, could produce their power more cheaply from a single steam plant than from the double plant.

"It is true that fuel is saved, if steam is not required for other purposes than power, during such times as the engine is not run; but it is also true that as the engine is only to run for a portion of the time, it is probably deemed advisable to purchase a low cost steam plant in order to reduce the fixed expenses, which means a larger consumption per hour than there would be with a better plant. At times also the engine will be unloaded, which is not conducive to economy. To the running expense must be added the cost of maintenance of a double plant, so that the cost is almost sure to be more than that of a single new efficient plant.

"If the stream is variable and the water-power plant is the only source of power, which must stop for a portion of the time, it would be of very little value under such conditions except for a very limited range of business. No business, employing any amount of labor, carried on in such a way, could compete successfully with concerns which have a continuous run."

WATER POWER IN FORMOSA.

In reply to a communication from the editor of a Manila journal concerning irrigation in Formosa, Consul Julean H. Arnold, of Tamsui, transmits a report, from which the following information is taken: Besides irrigation works, there are many public works now being constructed. In north Formosa: Keelung, harbor improvement to cost $3,000,000; water works for Taihoku, $946,000, and an electric generating plant at the same place, $731,000; construction of buildings for the Formosa Central Laboratory, $256,000; Agincourt Island lighthouse, $111,000; building for middle school for Japanese, $92,000. In south Formosa: Takon, harbor works, $2,357,000; railway extension work, $996,000; post and telegraph office at Tainan, $51,000. On the Taito Railway $2,120,000 will be spent during the next four years, and the Formosan Government railways will spend $1,245,000 during the next two years in construction work. The irrigation works which begin this year, and which will extend over a period of eighteen years, involve an expenditure of nearly $15,000,000. The problem of irrigation is chiefly concerned with the plains which make up the western half of Formosa. With a proper system of irrigation, the southern half of the western lowlands should be able to supply Japan with all the sugar it consumes, about 500,000 tons, which is sevenfold the amount now produced in this island, and with the same proper system it is estimated that the island's present rice fields could produce 50 to 75 per cent more than is now produced, in addition to which 100,000 acres, now non-productive for lack of irrigation, could be converted into rice fields. In addition to twelve main canals, of an aggregate length of 295 miles, a dam of 90 feet high and 1,800 feet in width will be constructed on the upper Taikokan River, where it will be possible to store 7,000,000,000 cubic feet of water, and near the mouth of the lower stream another dam will be constructed, from which will lead a canal 45 miles in length. A dam 90 feet in height and 1,140 feet in width will be constructed in the upper course of the Nisoko where 3,270,000,000 cubic feet of water may be stored, and from which a canal 50 miles in length will lead. These two dams will provide sufficient water to irrigate 48,000 and 50,000 acres, respectively.



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Water in motion has a peculiar resemblance to several other more complex physical phenomena. These can be better explained by a comparison of similarities than by any other method. Just as short, familiar Anglo-Saxon words often express our thoughts more clearly than do words of Greek origin, so does our intimate knowledge of moving water enable it to explain many subjects more clearly than do mathematical formulae. Simple analogies are of great assistance alike to the novice and to the adept. Many metaphorical examples may be given, but one of the earliest scientific analogies was used by Vitruvius, in the first century of this era:

THE HYDRAULIC ANALOGY.

"The voice is a flowing breath, made sensible to the organ of hearing by the movements it produces in the air. It is propagated in infinite numbers of circular zones, exactly as when a stone is thrown into a pool of standing water, countless circular indulations are generated therein, which, increasing as they recede from the centre, spread out over a great distance, unless the narrowness of the locality, or some obstacle, prevent their reaching their termination; for the first line of waves, when impeded by obstructions, throw by their backward swell the succeeding circular lines of waves into confusion. Conformably to the very same law, the voice also generates circular motions; but with this distinction, that in water the circles remaining upon the surface, are propagated horizontally only, while the voice is propagated both horizontally and vertically."

Of the more modern hydraulic analogies, one of the most useful is that employed in explaining electrical phenomena, whose intangibility causes it to elude our understanding. The familiar illustration of a man swimming in a current to indicate magnetic deflection, was first used by Ampere. In elementary books the electric current is often likened to water flowing under pressure in a pipe. The resistance of the wire is compared to the friction in the pipe, the amount of current to the volume of water delivered, and the voltage due to the difference of potential to the pressure due to the difference of water level. One writer has carried this analogy further, representing the inductance of an alternating current by a water-wheel carrying a heavy fly-wheel, the lag corresponding to the inertia of the wheel. He explains condenser and capacity phenomena by means of a chamber with two outlets divided by a flexible rubber diaphragm that stores excess energy.

The hydraulic analogy is also useful in explaining the action of steam in turbines. Just as all hydraulic turbines may be grouped under two main heads of reaction and impulse wheels, so may steam turbines. Hero's turbine, first used by the priests of ancient Egypt, employed the reaction principle, as does also the Parsons, Schulz, and Zolly. Branca's turbine of the seventeenth century was simi.ar in action to the impulse water-wheel, as are likewise the De Laval, Rateau, and Curtis. The impulse turbine, whether water or steam, utilizes the velocity of the moving fluid, while the reaction wheel employs both velocity and pressure. Water pressure is due

to head, steam pressure to expansion, which imparts a high velocity to the steam particles and causes them to act on the wheel-vanes so as to produce rotation. The essential principles of the flow of water in pipes have been successfully applied to moving gases, and many other instances will probably suggest themselves to the reader.

An analogy might well be termed an engineer's parable. Both parable and analogy are based upon a simple likeness from which deeper relations may be inferred by comparison. Certain moral truths are made more easy of comprehension by means of parables. Similarly, many scientific facts are more easily understood through analogy. In using this powerful tool, however, there is one precaution to be observed—while phenomena may be analogous, they are not identical, and care should be taken to prevent the idea presented by analogy obtaining so firm a hold on the observer's mind as to blind him to realities. It should be remembered that a comparison is a concession, that it is usually given to supply a lack of technical knowledge, and is to that extent misleading. An analogy is an aid to understanding, but not a substitute for it.

PERSONAL.

A. W. Paine has charge of the new office opened by the Crocker-Wheeler Company in the Gumbel Building, Kansas City, Mo.

Harvey Hubbell, of Bridgeport, Conn., accompanied by Mrs. Hubbell, returned on August 29th from a two months' trip abroad.

W. J. Davis, Jr., has been appointed engineer of the San Francisco office of the General Electric Co., succeeding J. A. Lighthipe.

H. G. Mead, general sales manager Henshaw, Bulkley & Co., San Francisco, has returned from a trip East. A. J. Turner, engineer for the same company, is expected home the latter part of this week.

Albert J. Marshall announces that he has recently severed his connection with the engineering department of the Holophane Company and has associated himself in the capacity of chief consulting and designing illuminating engineer with the Bureau of Illuminating Engineering, 437 Fifth Avenue, New York City.

CIVIL SERVICE EXAMINATIONS.

The United States Civil Service Commission announces an examination on September 9-10, 1908, to secure eligibles to fill a vacancy in the position of civil engineer and superintendent of construction, at $1,500 per annum, in the Quartermaster's Department at Large, New London, Conn., and vacancies requiring similar qualifications as they may occur in any branch of the service. The examination will consist of mathematics (elementary problems in mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics up to and including calculus); theory and practice of surveying and use and care of instruments (comprising transit, including stadia work, level, plane table, rods, chain, tape, etc., surveying, leveling, and other field work required in civil engineering); building construction, specifications, etc. (involving good knowledge of all materials employed in first-class buildings and of details of construction and of specifications); training and experience (rated on application).

TRADE CATALOGUES.

Luitwieler Pumping Engine Co., of Los Angeles, Cal., send a handsome catalogue of Automobile Fire Fighting Apparatus.

The Monarch Electric & Wire Company, of Chicago, have issued a new illustrated supply catalogue, containing about 900 pages.

Multiphase Revolving-Field Belted Generators are shown in detail in Bulletin No. 1108 from the Fort Wayne Electric Works, of Fort Wayne, Indiana.

Chas. C. Moore & Co., engineers of San Francisco, have issued a pamphlet descriptive of the Redondo plant of the Pacific Light & Power Co., which they will send to those interested, on receipt of request.

"How to Preserve Gauge Glasses" is told in booklet 8201 from the H. W. Johns-Manville Co., 100 William Street, New York City. It describes the Gilbert gauge washer, which makes a permanently tight joint on superheated steam.

A series system utilizing Tungsten lamps is fully described in Bulletin No. 4607, just issued by the General Electric Company, Schenectady, N. Y. This description includes illustrations and general data on transformers, switch-boards, lamp brackets and reflectors, series sockets and lightning arresters, used in connection with the system.

In Bulletin No. 4610, issued by the General Electric Company, Schenectady, N. Y., is described a new line of small plant continuous current switch-boards. The boards are manufactured for 125 and 250-volt circuits only, and each panel forms a separate and complete switch-board not intended for combination with other panels.

The Westinghouse Three-Wire Direct-Current System is explained in Circular No. 1088 from the Westinghouse Electric and Manufacturing Co., of Pittsburg, Pa. By means of this system only one generator is required to supply a three-wire balanced voltage service. This circular also contains a description of the generator by which this is accomplished.

The General Electric Company, Schenectady, N. Y., has issued an attractive folder in which it describes its mercury arc rectifier and the method of use in connection with moving-picture machines. The reason for the use of the mercury arc rectifier in this connection is that it enables the operator to obtain direct current from an alternating-current circuit, thus securing the best light at low cost.

The Type F, Form K-7 oil switch manufactured by the General Electric Company, Schenectady, N. Y., is described in Bulletin No. 4575. Completely enclosed air-break switches have been used where special protection from fire has been necessary, but the oil switch is recommended as best adapted for this purpose, and is suitable for use in cotton, flour, powder, or saw mills, or for electric installations in connection with oil pumping and refining plants. The switch is made for 600 volts, 650 to 300 amperes, and 2,500 volts, 50 amperes. It can be furnished with automatic tripping device and low voltage release.

REMOVAL NOTICE.

The Rix Compressed Air and Drill Co. have removed their offices to 371 Market Street, San Francisco. The machine shop will be located at 219 Spear Street, which has been occupied as temporary offices until now.

TRADE NOTICES.

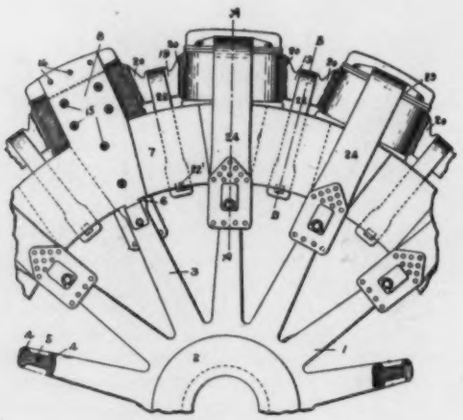
Byron Jackson Iron Works have opened a San Francisco sales office at 351-355 Market Street.

W. A. Purcell has been appointed San Francisco representative of the Moon Vibrator Co. of Chicago, Ill.

PATENTS

DYNAMO-ELECTRIC MACHINE. 896,323. Henry G. Reist, Schenectady, N. Y., assignor to General Electric Company.

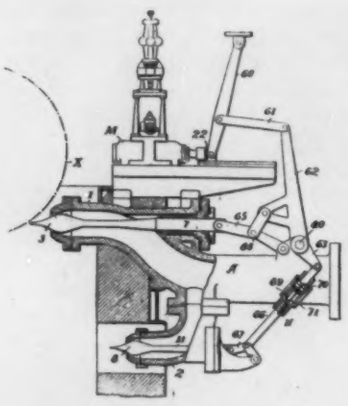
A field magnet made up of similar sections, each section having a short polar portion and a long polar portoin, said



sections being assembled so that the long portions in each pole are separated by short portions, and pole tip members located between the long portions and having their outer edges flush with the outer ends of the poles.

IMPACT WATER-MOTOR. 896,442. William A. Doble, San Francisco, Cal., assignor to May E. Doble, Alameda, Cal.

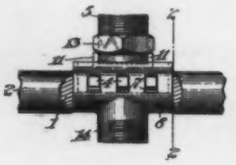
In an impact water motor the combination with a wheel provided with radial blades, a jet nozzle and valve within the



same, a compensating nozzle and valve, and lever connections between the two valves in which a lost motion is provided to allow the main valve to close to about three-fourths its total extent before opening the compensating valve.

BRANCH CONNECTION FOR ELECTRIC CABLES. 896,200. John J. Dossert, New York, N. Y., assignor to Dossert & Company.

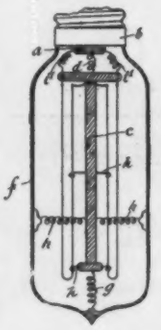
A branch coupling for electric cables comprising a pair of engaging conducting yokes adapted to be brought into contact with the cable on diametrically opposite sides thereof, and



means for compressing the cable between the said yokes, such means consisting of slots in one of the coupling yokes, corresponding lugs on the other coupling yoke and a nut, one of the said yokes being provided with coupling means for a branch conductor.

ELASTIC SUSPENSION FOR THE FILAMENTS OF ELECTRIC INCANDESCENT LAMPS. 896,092. Paul Druseidt, Remscheid, Germany.

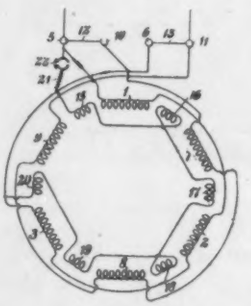
In an electric filament lamp, a rigid filament carrier, a



spiral suspension spring secured to said carrier, an independent filament holder secured to said spring and a spring connecting the opposite end of said holder with an adjacent portion of the bulb.

WINDING FOR SINGLE-PHASE INDUCTION MOTORS. 896,217. Fred R. Kunkel, Edgewood Park, Pa., assignor to Westinghouse Electric & Manufacturing Company.

In an electric motor, the combination with a main winding comprising two sections adapted to be connected in either series or parallel relation and severally composed of a plu-



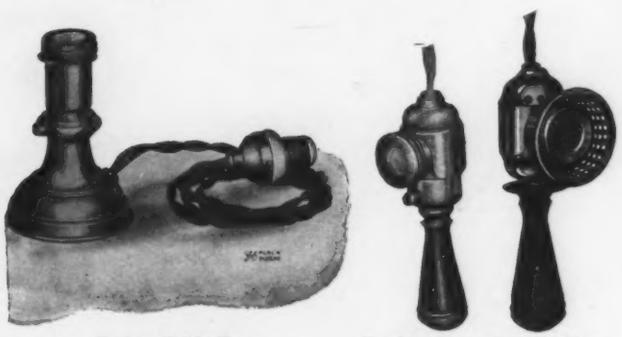
rality of groups of coils so disposed that the groups of one section alternate with those of the other, of an auxiliary winding comprising groups of coils which are symmetrically disposed with reference to the groups of the main winding sections and are connected in series with each other and in parallel with one of the sections of the main winding.

INDUSTRIAL

A NEW LINE OF CIGAR LIGHTERS

Cigar lighters for both continuous and intermittent service are now being manufactured by the General Electric Company, and may be obtained in the pendant, desk or table types. These cigar lighters are suitable for operation on either alternating or direct-current circuits, and may be readily connected to any ordinary lamp socket.

For intermittent service both the pendant and table types are available, but the pendant type only is suitable for continuous operation. Those for intermittent service are equipped with a push-button for closing the circuit during the period of operation, which is generally from four to six seconds. The continuous service lighters are nominally left in circuit, but have a snap-switch for turning the current off when not in use.



Desk or Table Type Intermittent — **Pendant Type Intermittent** — **Pendant Type Continuous**

The heating unit is somewhat similar in appearance to the ordinary fuse plug, and for intermittent service consists of several lengths of coiled wire lightly cemented to a thin sheet of insulating compound. The ends of the wire are connected to terminal screws in the porcelain plug base, which is screwed into a socket in the body of the lighter. A thin piece of perforated mica placed in a metal cap fitted to the porcelain plug base protects the heating coils. To light the cigar or cigarette it is only necessary to place the end against the perforated disk, the hot air, drawn through the holes in the mica, igniting the cigar even before the mica disk becomes red.

The intermittent desk type, as shown in the illustration, is compact and simple in design, the heating element being similar to that used in the intermittent pendant type.

The construction of the plug for continuous service is similar to that for intermittent service, except that the coils of wire are completely filled with cement between turns. With this unit no mica covering is used, as a perforated insulating compound placed on the top of the heating unit conducts the heat to the cigar. As will be noted in the illustration, these plugs are surrounded by a perforated metal mouthpiece which protects the plug and also prevents the liability of any one being burned by coming in direct contact with the heating element. In this type of cigar lighter, the heating plug cannot be removed without the use of a special spanner. This feature is of special importance when the lighters are used in public places, such as hotels, cigar stores, etc.

These cigar lighters are made for voltages from 95 to 125 volts. The power consumption is very low, being seventy-five watts for the intermittent type, and twenty-five watts for the continuous type. The cost of operation and the life has been determined after a series of careful tests. It was found that with the intermittent type 1,000 lights could be obtained at an approximate cost of one cent where power is sold for ten cents per kilowatt hour. The continuous service lighter can be operated at a cost of about three cents per day. The durability tests show that the intermittent type will give about 22,000 lights before deterioration of the heating element occurs. Tests now being conducted on the continuous service types show a maximum of over 5,000 hours at the present time. These tests are still in progress so that this value will be exceeded.

The cigar lighters of the intermittent type are finished in oxidized copper, the continuous service types being given a nickel-plated finish. All types are furnished with a suitable cord and attaching plugs.

SALES OF SMALL CURTIS TURBINES.

The increasing use of small Curtis steam turbines is strikingly shown by an inspection of a partial list of turbines under 500-kilowatt capacity, which, up to the present time, have been installed by the General Electric Company, or are under construction. Of the 570-odd turbines listed, representing a total capacity of about 37,000 kilowatts, seven per cent are for the export trade. The remainder are intended for domestic service in central stations, marine work, laboratories of educational institutions, power and lighting plants for hotels and office buildings, laundries, mines, printing establishments, and in every branch of manufacturing. It is interesting to note the widely-different industries in which small Curtis steam turbines are used. Among the list are woodworking plants, foundries, iron and steel mills, distilleries, chemical plants, ice plants, textile mills, breweries, tanneries, flour mills, shoe factories, paper mills, machine shops, and ammunition manufacturing plants.

Turbines for train lighting are finding a ready market, and it is interesting to note that the leading railroads are using this method of train illumination. The latest application of moderate-size Curtis turbines is for driving fire pumps, in which capacity they have been very satisfactory. On board ship, where a compact generating unit is required, small turbine lighting sets are also rapidly coming into favor.

HENSHAW, BULKELEY & CO. AT HOME.

Henshaw, Bulkeley & Co., of San Francisco, engineers and machinery merchants, have moved into their per nanent offices and salesrooms on Fremont Street, near Market. Soon after the fire they established themselves at 219 Spear Street, awaiting the completion of their new location. This has been designed especially for their needs and is a model of economy of space combined with every facility for the ready dispatch of business. The main floor is occupied by the various offices of the sales department which are arranged on either side of a central court. Below this the large basement is devoted to a display room, giving ample space to suitably display engines, boilers, mining machinery, hoists, blowers, and other lines that they handle.

On the gallery of the first floor are the filing department and the telephone exchange. The former is most elaborate, with much space for filing catalogues and correspondence. The second floor is occupied by the executive and accounting offices, the front being utilized for the draughting rooms. Visiting engineers and contractors are cordially invited to inspect these new quarters and to read the files of technical and trade journals which are preserved for ready reference. The progressiveness of the firm is shown not only in their handsome offices, but also in the efficient corps of salesmen and engineers employed, to whom credit is due for the large business that has been built up during these strenuous times.

TRADE MARKS

Classified List of Advertisers, Manufacturers, Manufacturers' Agents and Dealers, with Classes of Material They are Prepared to Furnish.

There is a court of arbitration to which the manufacturer can appeal without the consent of his competitors. It is composed of the great buying public—the consumer—who will listen with a willing and eager ear to the story of quality.

Take your case before this court, and convey to it the enthusiasm you feel for your goods. Clinch this enthusiasm with your strongest arguments and state your reasons for appreciation.

SHOW YOUR TRADE-MARK

Explain how this trade-mark or name will identify your goods, prevent substitution and protect the purchaser. If this be properly done, victory will be yours.

Bold face type shows manufacturers and manufacturers' agents. Italics show jobbers who carry a complete line of these goods.

ADAPTERS

LAMP ADAPTERS

Benjamin Electric Mfg. Co.
Dale Co.
General Electric Co.
Marshall Elec. Co.
Western Electric Co.

ALARMS

BURGLAR ALARMS

Electric Goods Mfg. Co.
Partrick, Carter & Wilkins Co.
Western Electric Co., "Edwards."
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

FIRE ALARMS

Western Electric Co., "Edwards."

WATER ALARMS

Partrick, Carter & Wilkins Co.

ANCHORS

Klein & Sons, Mathias.
**Brooks-Follis Electric Corpn.*
**B. F. Kieruiff, Jr. & Co.*
**Holabird-Reynolds Electric Co.*
**Klein & Sons, Mathias*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

ANNUNCIATORS

Electric Goods Mfg. Co., "Ross," "Rivol," "Perfect," "Noxall."
Partrick, Carter & Wilkins Co., "King."
Standard Electrical Works, "C. & S."
Western Electric Co., "Edwards."
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

ARMS

CROSS ARMS

Western Electric Co., "Walworth & Neville."

MAST ARMS

Electric Appliance Co., "Cutter."
Ft. Wayne Electric Works.
Western Electric Co., "Fletcher."

TELEPHONE TRANSMITTER ARMS

Dean Electric Co.
Electric Appliance Co., "Ecico"
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

ASBESTOS

Johns-Manville Co., H. W.

BATTERIES

OPEN AND CLOSED CIRCUIT WET BATTERY

Electric Goods Mfg. Co., "Samson," "Noswas."
Western Electric Company
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

DRY BATTERIES

Electric Appliance Co., "1900."
Electric Goods Mfg. Co., "Samson Semi-Dry."
Western Electric Co., "Blue Bell," "Liberty."
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co,*
**Holabird-Reynolds Electric Co.*
**Western Electric Co.*
**Standard Electrical Works.*
**Sterling Electric Co.*

MEDICAL BATTERIES

Partrick, Carter & Wilkins Co.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co,*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works.*
**Sterling Electric Co.*
**Western Electric Co.*

STORAGE BATTERIES

Electric Storage Battery Co.,
Westinghouse Machine Co.

BELLS

ELECTRIC BELLS

Electric Appliance Co., "Ansonia."
Electric Goods Mfg. Co., "Victor," "Dandy," "Tyrolean."
Partrick, Carter & Wilkins Co.
Western Electric Co., "Hawthorne," "Rex," "Lungena."
**Brooks-Follis Electric Corpn.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

Classified List of Advertisers—Continued

ELECTRO-MECHANICAL GONGS

Electric Goods Mfg. Co.
Marshall Elec. Co.
Partrick, Carter & Wilkins.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

MAGNETO BELLS

Dean Electric Co.
Electric Appliance Co., "Eaco."
Electric Goods Mfg. Co.
Kellogg Switchboard & Supply Co.
Standard Electrical Works, "C. & S."
Western Electric Co.
**Brooks-Follis Electric Corpn.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

BOILERS

Chas. C. Moore & Co., "B. & W."
Keystone Boiler Wks., "Parker."
Standard Elect'l Wks., "Robb-Mumford."
Tracy Engineering Co., "Edgemoore."

BOXES

WALL BOXES

Benjamin Elec. Mfg. Co.
Bossert Elec. Const. Co., "Bossert."
Chase-Shawmut Co., "Knockout."
Chicago Fuse Wire & Mfg. Co. "Union."
Cutter Co., The, "Munit."
Electric Appliance Co., "T. & B."
General Electric Co.
Harvard Elec. Co.
Holabird-Reynolds Elec. Co.
John R. Cole Co., "Bossert."
H. Krantz Mfg. Co., "De Rycke."
Standard Elect'l Wks., "M. & M."
**Brooks-Follis Electric Corpn.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

BRACKET

DESK TELEPHONE BRACKETS

Dean Electric Co.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co,*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

IRON POLE BRACKETS

Benicia Iron Works
Electric Appliance Co., "Cutter."
Pierson, Roeding & Co.
Western Electric Co., "Fletcher."

BURNERS

ELECTRIC GAS LIGHTING BURNERS

Western Elec. Co., "Edwards."
**Brooks-Follis Electric Corpn.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

CABLES

SUBMARINE AND LEAD-COVERED

American Electrical Works.
Electric Appliance Co., "Paranite."
Electric Appliance Co.
Habirshaw Wire Co., "Habirshaw."
National Conduit & Cable Co., "National."
Roebling's Sons Co., John A., "Tolma."
Safety Ins. Wire & Cable Co.
Standard Elect'l Works, "Simplex."
Standard Underground Cable Co.
The Simplex Elect'l Co., "Simplex."
Western Electric Co.
Western Electric Co., "Hawthorne."

CARBONS

ARC LIGHT CARBONS

Brooks-Follis Elec. Corp'n, The, "Siemens."
Reisinger, Hugo, "Electra," "Nuernberg."
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co,*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works.*
**Sterling Electric Co.*
**Western Electric Co.*

CIRCUIT BREAKERS

Cutter Co., The, "I.T.E.," "Dalite."
Ft. Wayne Electric Works.
General Electric Co.
Kieruiff, Jr., & Co., B. F., "Hartman."
Western Electric Co., "I. T. E." "Dalite."

CLEATS

PORCELAIN CLEATS

General Electric Co.
Holabird-Reynolds Electric Co., "Electric Porcelain."
Weber Electric Co., H. D. Sears general sales agent.
Western Electric Co, "Thomas."
**Brooks-Follis Electric Corpn.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

CLUSTERS

FIXTURE CLUSTERS

Benjamin Electric Mfg. Co., "Anti-Night."
Dale Co.
General Electric Co.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*
**Western Electric Co.*

COILS

ARMATURE AND FIELD COILS

General Electric Co.
Western Electric Co., "Deltabeston."
Westinghouse Elec. & Mfg. Co.

INDUCTION COILS

Electric Goods Mfg. Co.
Partrick, Carter & Wilkins Co.
Western Electric Co.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co,*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works.*
**Sterling Electric Co.*
**Western Electric Co.*

SPARK COILS

American Electrical Works.
Electric Goods Mfg. Co.
Western Electric Co.
**Brooks-Follis Electric Corpn.*
**Electric Appliance Co.*
**Holabird-Reynolds Electric Co.*
**Standard Electrical Works*
**Sterling Electric Co.*

COMPOUNDS

BOILER COMPOUNDS

Dearborn Drug & Chemical Works.
Johns-Manville Co., H. W., "Magic."